WHAT WE CLAIM IS:

1. A prism optical element comprising a plurality of surfaces facing each other across a medium having a refractive index (n) larger than 1 (n>1),

wherein said plurality of surfaces include a first surface having both a transmitting action through which light rays enter said prism optical element or exit therefrom and a reflecting action by which light rays are internally reflected in said prism optical element; a second surface disposed to face said first surface across said medium and having a reflecting action by which light rays are internally reflected in said prism optical element; a third surface disposed substantially close to said second surface to face said first surface across said medium and having a reflecting action by which light rays are internally reflected in said prism optical element; and a fourth surface having such a transmitting action that when said first surface has an action through which light rays enter said prism optical element, said fourth surface has an action through which light rays exit from said prism optical element, whereas, when said first surface has an action through which light rays exit from said prism optical element, said fourth surface has an action through which light rays enter said prism optical element, and

wherein the following condition is satisfied:

$$\sin^{-1}(1/n_d) \leq \theta_{r3} \leq 60^{\circ} \quad \ldots(1)$$

where n_d is a refractive index for the spectral d-line of said medium, and θ_{r3} is an angle of internal reflection

of an arbitrary light ray at said third surface.

2. A prism optical element according to claim 1, which satisfies the following condition:

$$\sin^{-1}(1/n_d) \leqq \theta_{r3} \leqq 50^{o} \quad \ldots(2)$$

3. A prism optical element according to claim 1 or 2, wherein reflection at said first surface is total reflection.

4. A prism optical element according to any one of claims 1 to 3, wherein the refractive index (n) of said medium is larger than 1.3 (n>1.3).

5. A prism optical element according to any one of claims 1 to 3, wherein at least one of surfaces constituting said prism optical element is a plane surface.

6. An observation optical system comprising the prism optical element according to any one of claims 1 to 5, said prism optical element being disposed in an observation optical system unit.

7. An observation optical system according to claim 6, wherein said prism optical element is disposed in an objective lens.

8. A camera finder optical system comprising the observation optical system of claim 6, wherein said prism optical element is disposed behind an objective lens in image erecting means for erecting an object image formed by said objective lens.

9. A camera finder optical system according to claim 8, wherein said prism optical element has an ocular lens action in addition to an image erecting action.

10. A head-mounted image display apparatus comprising:

the prism optical element according to any one of claims 1 to 5;

image forming means disposed to face said fourth surface of said prism optical element; and

a retaining member that retains both said prism optical element and said image forming means on an observer's face,

wherein a bundle of light rays emitted from said image forming means enters said prism optical element through said fourth surface and passes sequentially along an optical path in said prism optical element such that the light rays are reflected successively by said third surface, said first surface and said second surface and exit from said prism optical element through said first surface.

11. An image observation apparatus comprising image forming means and an ocular optical system having an action by which an image formed by said image forming means is led to an eyeball of an observer,

wherein said ocular optical system includes a prism member having at least three surfaces, wherein a space between said at least three surfaces is filled with a single medium having a refractive index (n) larger than 1 (n>1),

said prism member having an action by which light rays emitted from said image forming means are internally reflected at least three times, wherein at least two of the at least three internal reflections are total reflections, and wherein at least one of the at least two total reflections is performed by a surface disposed on a side of

said single medium that is closer to said observer, said surface being curved so as to correct aberrations produced by the internal reflections in said prism member, and

wherein at least two of the at least three surfaces of said prism member are disposed to face each other such that an external scene can be observed through said at least two surfaces, and that a distortion produced when the external scene is observed through said single medium is minimized.

12. An image observation apparatus comprising image forming means and an ocular optical system having an action by which an image formed by said image forming means is led to an eyeball of an observer,

wherein said ocular optical system includes at least a prism member,

said prism member having at least four optical surfaces having a transmitting or reflecting optical action, wherein a space surrounded by said at least four optical surfaces is filled with a single medium having a refractive index (n) larger than 1 (n>1),

said at least four optical surfaces including a first surface having both a transmitting action and a reflecting action and disposed on a side of said prism member that is closer to said observer's eyeball; a second surface having a reflecting action and disposed to face said first surface across said medium, said second surface being at least decentered or tilted with respect to an observer's visual axis; a third surface having a reflecting action and disposed to face said first surface across said medium at a

position substantially adjacent to said second surface; and a fourth surface disposed such that one end thereof is substantially adjacent to said first surface, and the other end thereof is substantially close to said third surface,

wherein at least said third surface has a totally reflecting action, and said first surface, said single medium and said third surface are arranged to have an external-scene observation action by which an external scene can be observed through said first surface, said single medium and said third surface.

13. An image observation apparatus according to claim 12, wherein said image forming means is an image display device having an image forming surface disposed to face said fourth surface, and said second surface is formed from a curved surface.

14. A head-mounted image display apparatus comprising:

the image observation apparatus of claim 13; and

a retaining member that retains both said image display device and said ocular optical system in front of the observer's eyeball,

wherein said prism member is arranged such that a bundle of light rays emitted from said image display device enters said prism member through said fourth surface, and the light rays are reflected successively by said third surface, said first surface and said second surface so as to exit from said first surface.

15. An image observation apparatus according to any one of claims 12 to 14, wherein said external-scene observation

action is formed such that a composite power of said first and third surfaces at at least one region of each of them is approximately zero.

16. An image observation apparatus according to any one of claims 12 to 15, wherein said first surface and said third surface are formed from curved surfaces, respectively.

17. An image observation apparatus according to any one of claims 12 to 16, wherein said first surface and said third surface are formed from spherical surfaces, respectively.

18. An image observation apparatus according to any one of claims 12 to 14, wherein said first surface and said third surface are formed from plane surfaces, respectively.

19. An image observation apparatus according to any one of claims 12 to 18, which satisfies the following condition:

$$-0.5 \leq \phi_{t1} \leq 0.5 \quad \text{(1/millimeter)} \qquad \ldots(3)$$

where ϕ_{t1} is a composite power of said first and third surfaces at respective arbitrary regions thereof.

20. An image observation apparatus according to any one of claims 12 to 19, wherein said prism member is fixed at a same position regardless of whether the observer views the image formed by said image forming means or an image of the external scene.

21. An image observation apparatus according to claim 20, wherein the image formed by said image forming means and the image of the external scene can be observed in respective partial regions through said first surface and said third surface.

22. An image observation apparatus according to any one of claims 12 to 19, wherein said prism member has switching means that causes observation modes to change between observation of the image formed by said image forming means and observation of an image of the external scene, said switching means having a function of moving said prism member.

23. An image observation apparatus according to claim 22, wherein said switching means moves said prism member such that an optical path extending from said prism member to said observer's eyeball to observe the image formed by said image forming means is approximately coincident with an optical path extending from said prism member to said observer's eyeball to observe the image of the external scene.

24. An image observation apparatus according to claim 22 or 23, wherein said switching means causes said prism member to move along a plane containing an optical path of an axial principal ray.

25. An image observation apparatus according to claim 22 or 23, wherein said switching means causes said prism member to move in a direction perpendicular to the observer's visual axis.

26. An image observation apparatus according to claim 22 or 23, wherein said switching means causes said prism member to rotate.

27. An image observation apparatus comprising image forming means and an ocular optical system having an action

by which an image formed by said image forming means is led to an eyeball of an observer,

wherein said ocular optical system includes at least a prism member,

said prism member having at least four optical surfaces having a transmitting or reflecting optical action, wherein a space surrounded by said at least four surfaces is filled with a single medium having a refractive index (n) larger than 1 (n>1),

wherein said at least four optical surfaces include a first surface having both a transmitting action and a reflecting action and disposed on a side of said prism member that is closer to said observer's eyeball; a second surface having a reflecting action and disposed to face said first surface across said medium, said second surface being at least decentered or tilted with respect to an observer's visual axis; a third surface having a reflecting action and disposed to face said first surface across said medium at a position substantially adjacent to said second surface; and a fourth surface disposed such that one end thereof is substantially adjacent to said first surface, and the other end thereof is substantially close to said third surface,

wherein at least said second or third surface has a totally reflecting action, and line-of-sight detecting means for detecting an observer's line of sight is disposed near a totally reflecting region of said second or third surface that has a totally reflecting action.

28. An image observation apparatus according to claim

27, wherein said prism member is arranged such that said first surface has a totally reflecting action.

29. An image observation apparatus according to claim 28, wherein said line-of-sight detecting means is disposed at a position where the observer's line of sight is detected through the totally reflecting region of said second or third surface.

30. An image observation apparatus according to any one of claims 27 to 29, further comprising illuminating means for illuminating said observer's eyeball.

31. An image observation apparatus according to claim 30, wherein said illuminating means uses infrared light.

32. A head-mounted image display apparatus comprising:

the image observation apparatus of claim 31; and

a retaining member that retains said ocular optical system, said image forming means and said line-of-sight detecting means on an observer's face.

33. An image observation apparatus according to any one of claims 10, 14 to 26 and 32, further comprising positioning means for positioning said image forming means and said ocular optical system with respect to an observer's head.

34. An image observation apparatus according to any one of claims 10, 14 to 26, 32 and 33, further comprising support means for supporting at least a pair of said image observation apparatuses at a predetermined spacing.

35. A prism optical element or prism member according to any one of claims 1 to 10 and 27 to 34, wherein said second

surface and said third surface act as different surfaces in terms of optical action but are formed structurally from a single surface.

36. A prism optical element or prism member according to claim 35, wherein said single surface constituting said second and third surfaces is arranged such that a region of said surface closer to said fourth surface acts as said third surface, and a region of said surface remote from said fourth surface acts as said second surface.

37. A prism optical element or prism member according to claim 36, wherein said single surface constituting said second and third surfaces is arranged such that a central region of said surface acts as both said second and third surfaces.

38. An image display apparatus comprising an image display device and an ocular optical system for leading an image formed by said image display device to an eyeball of an observer such that said image can be observed as a virtual image,

wherein said ocular optical system includes a decentered prism in which a space formed by at least two surfaces is filled with a medium having a refractive index larger than 1,

said at least two surfaces including a first surface positioned immediately in front of the observer's eyeball, and a second surface which is a reflecting surface facing said first surface, at least one of said at least two surfaces being a curved surface decentered or tilted with

respect to an observer's visual axis, and

wherein said ocular optical system further includes aberration correcting means disposed outside said second surface to correct aberrations due to decentration produced by said first and second surfaces with respect to light from an external scene.

39. An image display apparatus according to claim 38, wherein said aberration correcting means comprises a Fresnel lens.

40. An image display apparatus according to claim 39, wherein a center of an annular zone of said Fresnel lens lies in a plane containing an optical path of an axial principal ray from said image display device, and said Fresnel lens is decentered perpendicularly to the observer's visual axis in the plane containing the optical path of the axial principal ray.

41. An image display apparatus according to claim 39, wherein a center of an annular zone of said Fresnel lens lies in a plane containing an optical path of an axial principal ray from said image display device, and said Fresnel lens is tilted with respect to the observer's visual axis so as to extend along a surface configuration of said second surface.

42. An image display apparatus according to claim 38, wherein said aberration correcting means comprises a diffractive optical element.

43. An image display apparatus according to claim 38, wherein said aberration correcting means comprises a

holographic optical element.

44. An image display apparatus comprising an image display device and an ocular optical system for leading an image formed by said image display device to an eyeball of an observer such that said image can be observed as a virtual image,

wherein said ocular optical system includes a decentered prism in which a space formed by at least three surfaces is filled with a medium having a refractive index larger than 1,

said at least three surfaces including a refracting and internally reflecting surface positioned immediately in front of said observer's eyeball; an outside world-side internally reflecting surface disposed on an outside world side of said ocular optical system to face said refracting and internally reflecting surface; and a refracting surface through which a bundle of light rays emitted from said image display device enters said decentered prism, at least one of said at least three surfaces being decentered or tilted with respect to an observer's visual axis, and said at least three surfaces being arranged to perform at least three internal reflections, and

wherein said ocular optical system further includes a second optical element that cancels a power produced by said refracting and internally reflecting surface, which is positioned immediately in front of said observer's eyeball, and said outside world-side internally reflecting surface with respect to external light when an external scene is

observed through said two surfaces,

said second optical element being disposed on an outside world side of said outside world-side internally reflecting surface.

45. An image display apparatus according to claim 44, wherein said ocular optical system comprises a decentered prism in which a space formed by four surfaces is filled with a medium having a refractive index larger than 1,

said four surfaces including a first surface positioned on an observer's eyeball side of said ocular optical system and serving as both refracting and reflecting surfaces; a second surface which is a reflecting surface disposed to face said first surface; a third surface which is a reflecting surface disposed to face said first surface at a position adjacent to said second surface; and a fourth surface which is a refracting surface closest to said image display device,

wherein at least one of said four surfaces is decentered or tilted with respect to the observer's visual axis.

46. An image display apparatus according to claim 45, wherein at least one second optical element is disposed on an outside world side of said second or third surface so that an external scene can be observed through said first surface, said second surface and said second optical element or through said first surface, said third surface and said second optical element.

47. An image display apparatus according to claim 46,

wherein said second optical element simultaneously cancels a composite power of said first and second surfaces and a composite power of said first and third surfaces with respect to light from the external scene.

48. An image display apparatus according to any one of claims 38 to 47, further comprising positioning means for positioning said image display device and said ocular optical system with respect to an observer's head.

49. An image display apparatus according to any one of claims 38 to 48, further comprising support means for supporting said image display device and said ocular optical system with respect to an observer's head such that said apparatus can be mounted on the observer's head.

50. An image display apparatus according to any one of claims 38 to 49, further comprising support means for supporting at least a pair of said image display apparatuses at a predetermined spacing.

51. An image display apparatus according to any one of claims 38 to 48, wherein said ocular optical system is used as an image-forming optical system.

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